The Impact of the Sub-Fab on the Availability of EUVL

edwardsvacuum.com

Anthony Keen[‡†], Niall Walsh[†], Cansin Badan[†], Jos Donders[†]

[‡]Edwards Vacuum, Innovation Drive, Burgess Hill, RH15 9TW, UK, [†] Edwards Vacuum, De Run 6807, 5504 DW Veldhoven, the Netherlands

Availability of lithography tools is paramount for end-users in the strive towards high wafer throughput, and this is delivered by measuring everything that impacts the tool performance. The understanding of this availability has been captured in the SEMI E10 standard, which establishes a generic way of measuring equipment performance and productivity through the definition of six basic equipment states. The advent of EUV lithography introduces a new component to this matrix in the form of the need for a remote vacuum and abatement subsystem, which can ultimately have a direct impact on the availability of the NXE process tool.

Currently, semiconductor industry is increasingly turning to comprehensive and integrated equipment health monitoring information management to address emerging challenges. For this purpose, Edwards have introduced an upgraded tool-centric application, **EdCentra**, used for health monitoring of the sub-fab equipment. Remote connecting to the **EdCentra** application and Edwards in house subject matter experts enhances the response time for the predictive and corrective maintenance activities for improving tool operation and overall fab efficiency.

In this poster, we describe some key outputs of **Edwards's** availability analysis, which has highlighted the need for diagnostics capability for health monitoring via remote connectivity and specific system design choices to enable process continuation during maintenance activities as the most important contributors to improving the availability of the vacuum and abatement subsystem.

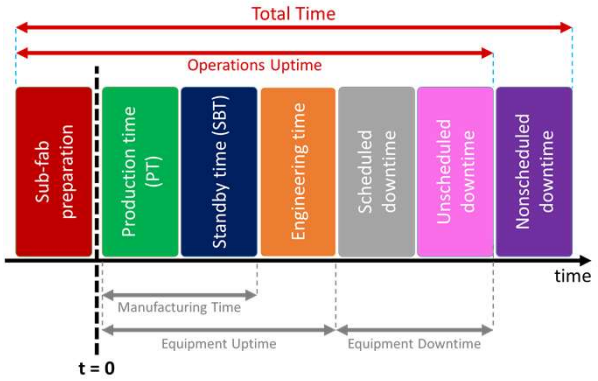
Fundamental equipment metrics: Semi E10[1] defines six key states (production time, standby time, engineering time, scheduled downtime, unscheduled downtime, nonscheduled downtime) related with the basic states and the projected function of the equipment. In addition to these six equipment states defined in the Semi E10 standard, we introduce one more key element, ***sub-fab preparation***, that has a significant effect on the operations uptime.

EUV Zenith enables the process via

- Vacuum pumping
- Abatement for safe H_2 processing
- NXE leak detection
- Intelligent design for reducing environmental footprint

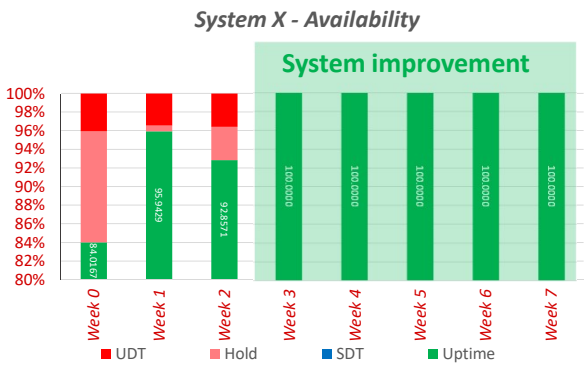
From the installation to the audit, the *sub-fab preparation* consists of several milestones. Any disruptions of these milestones can significantly delay the **production time (PT)** causing secondary **UnScheduled Downtime (UDT or USD)** of the equipment.

In order to minimize the USD state and enable a continuous operation, Edwards has developed a unique approach, beginning much earlier than the starting (***t = 0***) of the manufacturing time (**PT** + **Standby time (SBT)**).



As EUVL is on the brink of high-volume manufacturing (HVM)[2], Edwards, providing vacuum and abatement solutions in **every** EUV factory throughout the world, plays an important role in enabling continuous EUV availability. Currently, **Edwards**'s state of the art integrated system, EUV Zenith, achieve **> 99%** tool availability in the sub-fab and target to reach **99.9%** uptime before 2020.

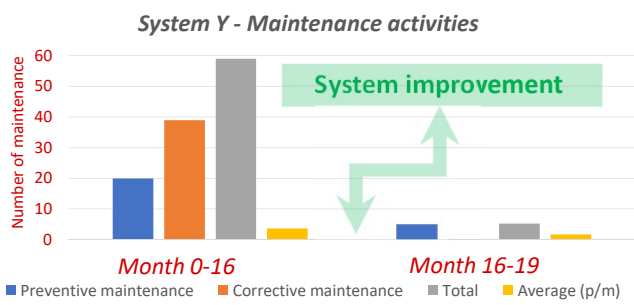
Although vacuum and abatement equipment is common place in semiconductor fabs, the vacuum and abatement sub-system for an EUVL tool presents a subtly different challenge to the conventional philosophy in the sub-fab. On one hand, the required availability on other process tools (such as CVD and etch) is restricted by the necessity to perform scheduled maintenance activities on those tools as well as the sub-fab equipment due to harshness of those processes. On the other hand, for EUVL 100% availability of the vacuum and abatement sub-system would ultimately be required so as not to restrict wafer throughput. Consequently, the ability of this vacuum and abatement sub-system to manage the process tool effluent continuously and safely in all tool states is integral to delivering maximum availability of the process tool.



The figure on the left exhibits the gain in *System-X* availability following the implementation of an improvement applied to an element .

As a result, USD has been reduced from 41.8 hours to 0 hours.

Maintenance activities are an important component of the availability matrix. The figure on the right exemplifies how a system improvement can influence the availability by reducing the average number of PM activities.



To minimize and ultimately remove the impact of a USD event Edwards plans preventive maintenance (SD) activities within the shadow of scheduled NXE maintenance. Ultimately the goal is to have zero SD interventions.

With the correct understanding of the root cause of the USD event this method has been proven to reduce the frequency of such USD events to zero. This understanding is more effectively enabled by the **EdCentra health monitoring** application, and allied with **remote connectivity** can result in a 6 hour gain on average in diagnostics time and further reduction of overall trouble shoot time.

EUVL platform has been in improvement for more than a decade and it is necessary to move towards more advanced technology to assess the platform's suitability for HVM[3, 4]. Scaling to high-volume manufacturing requires the key players to think ahead and prepare for the future early in the product lifecycle.

Edwards has initiated an availability program with a view to improving service times (Diagnostics, Access, Replacement and Recovery). As part of this initiative, an availability matrix was created examining existing scheduled and unscheduled down activities to facilitate this objective in accordance with SEMI E10. We have described some key aspects of the output of this analysis, which has highlighted specific design choices to enable process continuation during maintenance activities and the need for diagnostics capability as the most important contributors to the improving availability of the vacuum and abatement subsystem.

[1] SEMI E10-0814, Specification for definition and measurement of equipment reliability , availability, and maintainability (RAM) and utilization, 2015. [2] C. D. Young, BAML 2018 APAC TMT Conference, Enabling semiconductor innovation and growth: EUV lithography drives Moore's law well into the next decade, Taiwan, 2018. [3] Purvis, M., et al. Industrialization of a robust EUV source for high-volume manufacturing and power scaling beyond 250W, EUVL IX. Vol. 10583. SPIE, 2018. [4] Helfenstein, P., Rajeev, R., Mochi, I., Kleibert, A., Vaz, C. A. F., & Ekinci, Y. Beam drift and partial probe coherence effects in EUV reflective-mode coherent diffractive imaging. Opt. Express., 26(9), 2018.